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ABSTRACT

The effects of different types of feedback in computer assisted instruction were studied in 30 college students with different cognitive styles. The program, written in Apple Pilot and administered on an Apple IIE microcomputer, consisted of 16 problem solving tasks; for each, a graphic display and a textual question were presented. Two feedback treatments were used: knowledge of results--whether the response was correct or incorrect; and information--an explanation of the errors and strategies for correcting them. Cognitive styles, the moderator variables, were field dependence-independence and conceptual tempo (reflectivity-impulsivity). Four measures of performance were used as dependent variables: response time, error rate, number of attempts on each item, and number correct score. The results indicated that field dependent subjects had faster response times and fewer response errors when given an explanation of their errors and strategies for correcting them. Field independent subjects had lower response rates and fewer errors when given only an indication that an error had been made. Age and sex had minor effects on response time for some items. Conclusions regarding the design of feedback in courseware materials are included. (GDC)

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MATCHING FEEDBACK AND COGNITIVE STYLE IN VISUAL CAI TASKS

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Abstract

This paper describes an investigation into the design of feedback in CAI materials and how different cognitive styles (Field dependence and conceptual tempo) affect performance. The results of the study indicated that field dependent subjects have lower response times and fewer response errors when given feedback containing an explanation of their error and strategies for correcting their errors. Field independent subjects have lower response rates and fewer errors when given only an indication that an error has been made. The implications of these findings for the design of feedback in courseware materials are discussed.

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Computer courseware design contains the potential for incorporating complex visual information and individualized corrective feedback. Little emphasis has been placed on examination of the effects of individual differences on the acquisition of information from computer visuals and to the requirements these differences may represent in regard to the design of individualized feedback messsages. Thus, the purpose of this study was to examine the problem-solving strategies of learners in completing visually presented tasks, and to investigate the extent to which feedback designed on the basis of learner aptitudes and task requirements assisted or hindered learner's success in task accomplishment. More specifically, attention was given to the relationship between the type and organization of the content information in the feedback message (information feedback versus knowledge of results feedback) and the cognitive style of learners (field dependence and conceptual tempo) in determining the performance, and in particular, the time taken and the number of errors made in solving a series of graphically encoded problems. The study described in this paper investigated the strategies and performance of learners in the context of a visually based Computer Assisted Learning (CAL) program in order to contribute to the identification of specific criteria which might be considered in the design of feedback messages to assist learners with differing learning styles in improving their performance on tasks using visual information, and so that a greater understanding might be gained about the possible use of computer graphics, visual information and feedback in individualized learning materials.

The Visual Learning Task and the Individual: a Courseware Perspective.

Bork (1980) and Becker (1982) have pointed out, that with technological advancement, it is now relatively simple for even the novice to design courseware materials. General evidence suggests that visuals assist task achievement (Allen, 1975; Dwyer, 1978; Merrill and Bunderson, 1981) and developments in computer technology have facilitated the use of colour graphics in programs. Schneiderman (1980) has quoted the familiar cliche "a picture is worth a thousand words" in describing the possible use of visual information in programs, and Bork (1980) believes, with the use of relatively simple author languages, graphics can be included in a variety of courseware materials. The role of computer graphics in educational materials has been described by Bork (1977) as serving three functions: as a means of motivation, as a mechanism for the presentation of abstract concepts and as a tool in the development of problem-solving skills. Dwyer (1978) maintains that each instructional medium has unique characteristics which may be employed in completing specific tasks and according to Winn (1982) it is at the problem-solving level of task complexity that computer courseware materials offer the most potential for the learner, due to the computer's ability to offer individualized instruction and feedback. This study focused on the use of graphics in the development of problem-solving strategies.

Whilst computer graphics terminals have the potential for increasing the effectiveness of problem-solving activities through the dynamic manipulation of graphic representation, Becker (1982) raises the issue that the majority of CAL programs are based on textual information and research to date has dealt with the design of feedback in relation to textual or alphanumeric content information, utilizing large scale resources and expertise. Bork (1977) suggests that graphics may provide an alternative to alphanumeric codes, particularly for learners who are not competent in comprehending verbal information. Using the interactive

attributes of the computer the student has the benefit of both computer dialog (verbal information) and graphics (visual information). In describing the potential use of graphics though, Bork points out that relatively little is known about the use of visual information in education and Fleming (1983) has made note of the problems associated with the use of visual information in instruction when learners are required to utilize a strategy which may conflict with their own learning style in gaining information from the visual, or are restricted by a time limitation on the task (Kogan, 1971). Similarly Becker speaks of the problems of individualizing feedback, emphasizing the differing feedback requirements of individual aptitudes in order to accomplish specific types of tasks.

The process of learning from visuals has been theorised as a far more complex procedure than the behaviourist idea of stimulus-response learning (Knowlton, 1966; Goodman, 1968; Dwyer, 1978; Salomon, 1979). Salomon (1979) demonstrates this theoretical position in classifying the use of visual images in terms of the information or cognitive processing required. He contends:

> When there is a poor match between the modes of presentation and internally represented information, additional translations, conversions or elaborations are required.
> (Salomon 1979, p68)

In a similar way feedback may act to facilitate a match between the mode of presentation and the internal representation as described by Salomon.

Feedback in Computer Courseware Materials.

Enquiries into corrective feedback design may offer means of examining methods of creating truly individualized and interactive courseware materials. Kulhavy (1977) has loosely defined 'feedback' as the term used to refer to any of the numerous procedures or strategies used to tell a learner if his response is correct. Corrective feedback in CAL courseware is intended to deal specifically with responses which are incorrect. It is based on the hypothesis or principle that the more information the learner has about a response the better the response is understood. Logically increments in the complexity of the feedback message should produce increased learning.

Kulhavy (1977) has described the variation of levels of information used in feedback messages as a continuum. The components of the message on the simplest level present a knowledge of results (Annett, 1969; Kulhavy, 1977) simply acknowledging an error, but offering no content information which might assist in the correction of the error. As the continuum advances the message becomes more complex, not only indicating an error to the learner, but explaining the error and giving information feedback (Gilman, 1969; Tait, Hartley and Anderson, 1973) which is intended to guide the learner to the correct response. Messages comprising several elements may form a new instruction and can be an integral part of the instructional process, relating the technology to the task by utilizing its unique interactive attributes.

In proposing criteria for courseware design and evaluation several authors have suggested feedback as a component for investigation(Bork, 1980a; Gleason, 1981; Cohen, 1983; Jay, 1983; Hedberg and Myint, 1983). Cohen's summary presents a representative example. She has listed six

functions which feedback should fulfil in order to assume both an interactive and corrective role.

1. Feedback should be friendly and positive.
2. It should immediately provide a knowledge of results and in the case of an incorrect response, the correct answer and an explanation as to why the learner's response was wrong.
3. Over-emphasis of praise for the correct response should be avoided.
4. Feedback should provide a means of remediation or assistance in achieving the correct response.
5. Reinforcement of the wrong answers (e.g. by providing a more rewarding graphic) should be avoided.
6. Subject's age and level should be considered in determining the relevence of the information.

Whilst the above set of criteria may incorporate the feedback as an integrated function of the program, the effectiveness of it in relation to visual tasks in courseware has yet to be substantiated.

Although the design of the information feedback message is based on the hypothesis that learning should increase as the amount of information concerning a response increases, support for this hypothesis has been inconclusive. Kearsley et al (1982) have differentiated between reinforcement feedback and corrective feedback and have maintained that one of the weaknesses in courseware materials is due to the emphasis on it in programs as reinforcement. Reinforcement, according to Nelson (1976) relates to correct responses, corrective feedback should relate to task achievement strategies. Studies have indicated that the type of information in the feedback message may be crucial in determining the effectiveness of the message (Gilman, 1969; Tait, Hartley and Anderson, 1973).

A second difficulty encountered in designing corrective feedback has been the accomplishment of the interactive message, making the learner an active participant (Gagne, 1982) rather than a passive observer. Kearsley and Hillelsohn (1982) have described the interactive role of feedback as providing students with hints and ultimately the correct answer. Although a high degree of interaction has been demonstrated in large scale programs (Merrill, 1980), Becker (1982) has made note of the large data bank of response usually required in order to achieve interactive courseware materials, and Merrill (1980) has attributed the lack of such implementations in small programs, to the limitations of time, personel and resources.

While the design of feedback in simple drill and practice programs, usually presented as multiple choice response sequences, has posed fewer difficulties for corrective feedback design, due to the restricted choices of available solutions, the more interactive styles of the tutorial and simulation program have required greater attention and organization in the feedback design. Appropriate suggestions for the organization of information as interactive messages in small scale courseware materials such as tutorials, has been limited.

Cohen's (1983) suggestions have alluded to the role played by individual learner differences in determining the design of the feedback

message, in the consideration of age and sex, but the identification and organization of information which would constitute an explanation or error and remediation of errors remains a difficulty for designers as learners are not always consistent in their reasons for error.

Individual Learner Differences: The Concept of Cognitive Style.

The skills and aptitudes brought by the learner to the learning task influence to a great extent his performance on the learning task (Cronbach and Snow, 1977). The manner in which information is obtained, processed and utilised by the learner may determine their need for corrective feedback on visual tasks, the type of information required in the feedback or the way in which the information should be organised. In examining individual learner differences in information processing researchers have begun to use cognitive information processing theories in describing differences relevent to instruction (Grippin, 1973; Renzi, 1974; Boysen and Thomas, 1980; Benbasat and Dexter, 1982).

Cognition refers to both the product and process of thought, the acquisition of information and knowledge. An individual's manner of acquiring and processing information is commonly known as cognitive style. Cognitive styles contain several characteristics which make them an appropriate aptitude measure in the study of individual differences and their relationship to instruction (Kogan, 1971). Ausburn and Ausburn (1978) have described cognitive style as being concerned with the differences in the cognitive processes by which knowledge is acquired: differences in perception, thought, memory, imagery and problem-solving approaches.

The Field dependent/Independent dimension of cognitive style (Witkin et al, 1977) concerns an individual's ability to overcome embeddedness in a stimulus field through active and analytical participation and processing as opposed to a passive and global approach. This dimension of cognitive style has been related to the use of visual information in educational materials (French, 1983), has been held to be associated with the problem-solving strategies employed by learners (Witkin, 1977), and as the study by Boysen and Thomas (1980) indicated, has suggested that the type of information in the message and the organisation of the information may be crucial to the effectiveness of feedback design.

The Conceptual Tempo dimension of Cognitive Style is concerned with the degree to which a learner reflects on the validity of a solution or hypothesis before responding, in cases of response uncertainty. Messer (1976) found a correlation between the reflective/impulsive dimension of cognitive style (conceptual tempo) and performance on problem-solving tasks that contain response uncertainty. Ault (1973) examined the viewing behaviour of reflective and impulsive subjects as they related to the strategies employed in a problem-solving task and found that impulsive subjects showed a higher number of errors than reflective subjects whose viewing behaviour was more systematic and less global than their impulsive counterparts. In problem-solving tasks using visual information the tendency to reflection or impulsivity might be an important predictor of performance, particularly in relation to time and error under conditions of response uncertainty.

Feedback, Visual tasks and Cognitive style.

Few research studies have considered the relationship between field

dependence, conceptual tempo and the design of feedback in courseware materials, and little evidence is available concerning the use of feedback as it relates to field dependence/independence or conceptual tempo in materials using visual information in CAL courseware materials.

Grippin (1973), using both conceptual tempo and field dependence, examined the effects of the two cognitive style dimensions in relation to the use of strong and weak prompts and found a correlation between field independence and reflectivity and field dependence and impulsivity. The findings of Messer (1976), Ault (1973) and Grippin (1973) indicate that examination of conceptual tempo, in relation to field dependence and the use of visual information in problem-solving tasks may suggest factors which should be considered in the design of interactive individualized feedback. Renzi (1974) employed a feedback /no feedback treatment in a self-instructional program designed to examine the interaction between feedback and field dependence. The interaction was confirmed statistically and a large main effect for field dependence was found. Schwen (1970) found that the amount of organization of material influenced the performance of field dependent learners. With material that was already organized, very little difference in performance was found between field dependent and field independent subjects, but in materials which required organization field independent learners showed a higher performance. Besides indicating that the cognitive style of field dependence influenced subject's performance, the studies by Renzi (1974) and Schwen (1970) also indicated that the organization of the information may be influential in determining performance. These findings may be related to the organization of the information in the feedback message in courseware materials. Further, results of studies by Adams and Mcleod (1979) and Boysen and Thomas (1980) have suggested that differential modes of information used in the message may interact with the learners aptitude to effect performance.

Adams and McLeod (1979) dealt with Witkin's (1977) proposal that the ability to analyse a configuration reflects not only a perceptual skill, but a particular problem-solving approach. They presented subjects with two levels of feedback on a mathematics task. They found a significant interaction between pre-test and achievement scores, but the expected interaction between field dependence and achievement did not occur, although trends consistent with Witkin's theory were found. Adams and McLeod related the lack of a significant interaction to discrepencies in the materials and treatments used in the study. Their explanations tended to suggest that rather than guidance being a complete factor in the interaction, specific components in the information might be directly related to both the task and the degree of field dependence of the learner. These findings together with those of Boysen and Thomas (1980), who found a significant interaction between feedback and field dependence, have suggested that the type of information in the message may interact with the learner's aptitude to also effect performance.

In studies which can be related to investigations of feedback design and cognitive style, Cohen et al (1981) in a meta-analysis of studies of visually-based instruction found learner aptitudes played a strong role in determining performance on visual as well as verbal tasks. Koran, Snow and McDonald (1971) determined that the use of simple or complex visuals tended to interact with the type of learning task and the aptitude of the learner. Using the aptitude of field dependence they found that field independent subjects benefited more from a complex visual presentation than field dependents. French (1983) reported a significant interaction

between field dependence, the treatment and task in a concept attainment task involving the use of visual cues in an individualised learning package. The findings of Cohen et al (1981), Koran et al (1971) and French (1983) have suggested that individual learner differences may interact with the media attributes to affect performance on tasks involving visual information.

To summarise, research concerning the use of visual information in instruction has indicated the variable effects of visual information on performance, and the interaction of visual information with the cognitive style dimension of field dependence and conceptual tempo. Research on interactive instructional programs has, to date, not dealt with the use of feedback on tasks involving the use of visual information, however the findings of studies dealing with the design of feedback in alphanumerically based courseware materials have indicated that similar considerations, of task and cognitive style, and in particular, field dependence and conceptual tempo may apply in feedback designed in relation to visually-based tasks.

In line with the findings of research presented in the above discussion, the proposals of the study reported in this paper suggested that learners with differing cognitive styles would perform better on visual tasks with the assistance of an explanation of errors and the provision of strategies for disembedding information relevent to the correct response.

The Questions addressed in the study.

The following questions formed the basis of this investigation.

1. Does feedback designed to provide learners with an explanation of errors and incorporating strategies for disembedding relevent information assist learners in improving performance on tasks ?

2. Do subjects with different selected cognitive styles perform differently on tasks under conditions of differing feedback ?

3. Do selected measures of cognitive style interact with feedback designed to explain errors and provide strategies for disembedding information, to affect performance on tasks involving the use of visual information ?

METHOD

Thirty subjects participated in the study. Subjects were part-time or full-time students undertaking courses in education. Approximately equal numbers of males (N = 16) and females (N = 14) participated in the study. Ages ranged from early adulthood to mature age (Mean 31.4 years, s.d. 9.8). Teaching experience ranged from minimal (first year undergraduate field experience) to considerable (fifteen years or more). All subjects participated in the study on a voluntary basis.

A two group design was used in the study, allowing for examination of multiple factors, the between group variable being the treatment administered. The two treatments used were: Knowledge of Results feedback and Information feedback, field dependence and conceptual tempo being

regarded in this study as moderator variables. Each subject completed a total of sixteen graphically encoded tasks. Subjects were randomly assigned to one of the two treatment groups. Four primary statistical measures of performance were used as dependent measures in the study: response time, error rate, the number of attempts on each item and a score of correct responses. Observational data was also noted during data collection.

Experimental Materials

A computer program, constructed and administered on an Apple IIE Micro-computer was used in the study. Written in Apple Pilot, the program consisted of sixteen separate problem-solving tasks, each task incorporating a graphic display and a question presented in textual form (Fig 1).

Insert Figure 1 about here

Each task was designed to require the disembedding of information from a graphical representation in order to solve the problem. The first eight tasks in the program presented subjects with maps or diagramatic visuals, each diagram containing a visual error or having information missing from the visual. The graphics in the first section of the program were constructed as symbolic representations rather than pictorial structures (Merrill and Bunderson, 1981). These graphics were presented in contextual form, the context element being a tourist brochure from which each was said to be an extract. The graphics in the second section of the program presented an abstract problem to the learner, no contextual information being used in this section of the program (Fig 2).

Insert Figure 2 about here

The final three items acted as a test. These were essentially a repeat of three visuals from the first section of the program, having slightly different response requirements.

Two versions of the program were constructed, each with a different feedback design. In both versions of the program subjects were given five attempts on each of the first eight items. In the second section of the program subjects were given three attempts - from a five choice multiple choice selection. For the final three items one attempt only was available.

In the knowledge of response feedback treatment incorrect responses generated the phrase "That's not right...Try again". This message was designed to indicate to the subject that their response was not correct, but to also encourage them to pursue the correct answer. No explanation or reason for the error was given nor was any strategy provided to assist them in achieving a correct response. Given the knowledge of their incorrect response subjects were then left to their own resources to find the correct response. The final message for each item gave the same information, knowledge of the correctness of their response, and referred them to the next item in the program. The same format of verbal feedback was used in the second section of this version of the program. In the Information Feedback version of the program, the feedback message was

designed to provide three elements:

(a) knowledge of result.
(b) an explanation of the error.
(c) information to assist in developing a strategy to amend the error and minimize subsequent errors.

A new message was generated for each of four attempts, an incorrect fifth attempt producing the correct response. Each message sequentially offered more information to the subject, progressively simplifying the task, and successively disembedding the required information a little more.

In the second section of this version of the program, the feedback to the initial incorrect response consisted of both verbal and visual information. The message, as in the pre-ceeding tasks told the subjects that their answer was incorrect. The explanation for each item was the same, that some of the lines in the selection did not match the shape structures. The program then proceeded to suggest a strategy by placing one of the key lines from the figure onto the shape for the subject. This information was designed to begin the process of disembedding for the subject. Further incorrect responses to these tasks generated a verbal message, again designed to further simplify the embedded information, by focusing the subject's attention on relevent details within the figure.

Procedures

Subjects were informed that the experimenter was investigating the way in which people work through programs on a micro-computer and how the design of the program affects their performance. Each subject worked through the program individually, a reasearcher being present throughout. The experiment took place in a micro-computer laboratory, the equipment being set up in one corner of the room. The observer (researcher) was seated behind and to the right of the subject. The observer timed each response and recorded the status of the response and noted any reactions or comments from subjects. The question pertaining to each visual was phrased (a) to to require a minimum of keyboard and computing experience and to (b) maximize the factor of response uncertainty, referred to by Kagan (1965) as being characteristic of the determining factors of conceptual tempo.

Thus most of the responses required a single letter or number, or a simple response of a few words. Subjects were also instructed at the commencement of the program in the procedure of keying in a response. The introductory frame introduced the concept of the program to subjects asked for their help in solving the problems and asked for the subject's name. Subsequent questions then posed each problem to the subject, and presented feedback using the subject's name.

The Hidden Figures Test (French, Ekstrom and Price, 1973) was group administered to subjects to determine a measure of field dependence, the Matching Familiar Figures Test of Conceptual Tempo (Kagan, 1965) being used as a measure of conceptual tempo. A time interval of approximately one week occurred between the administration of these tests and subject's participation in the program. At the conclusion of each testing session subjects were invited to make any comments they would like about the tasks or the program, or any difficulties they may have encountered in completing the tasks.

Data Analysis.

The subprogram ANOVA from the Statistical Package for the Social Sciences was used to examine the relationship between the dependent measures of time, error, attempts, scores on the program items and Conceptual Tempo groupings. Derivation of a conceptual tempo score, using discriminant analysis, was undertaken following the procedures suggested by Hedberg (1976) to allow conceptual tempo to be included in the regression analysis. The contributions of the predictors field dependence, conceptual tempo, age, sex, treatment, treatment by conceptual tempo interaction and field dependence by treatment interaction were examined using the multi-variate multiple regression subprogram NEW REGRESSION from the Statistical Package for the Social Sciences. In the regression analysis new dependent measures were derived from the measures of time, error rate, the number of attempts and scores on individual items. Derived measures were used to examine main effects and interactions.

RESULTS

Feedback Information and Organization.

Means and standard deviations of response times by overall and treatment groups are presented in Table 1. No significant differences in response times (at the .05 level) were found between treatment groups on the total response times for tasks in the first section of the program, i.e. those tasks presented in the context of relational information, nor in the second section of the program, (the abstract graphics) although subjects in the Information Feedback treatment group tended to have longer response times. No significant differences were found on the response times on the three final test items in the set of tasks.

When analysing by individual items in the program differences were found to be significant on the seventh item, subjects in the Information Feedback treatment having a significantly longer response time than subjects in the Knowledge of Results treatment group. This trend was indicated in the response times for the other tasks in the program, but not to a statistically significant degree. These results indicated that the provision of information feedback may have caused subjects to consider their response for a longer period of time on particular items than did their counterparts in the Knowledge of Results group.

Insert Table 1 about here

Examination of first response times produced no definite trends in performance on the first eight tasks, but on the following tasks, based on the more abstract visual, differences between the means of the groups approached significance at the .05 level. Again for tasks in the first section of the program subjects in the Information Feedback treatment tended to have longer response times for their initial responses. Table 2 presents the means and standard deviations of response errors by the overall and treatment groups. Again differences between the treatment groups were not significant on the first eight tasks, although subjects in the information feedback treatment did tend to have a lower error rate than their counterparts in the Knowledge of Results treatment group. A similar trend occurred in the second set of tasks. Examination of first response errors also failed to produce significant differences, but the

tendency for subjects in the Information Treatment group to have fewer errors was also evident here. No significant differences were found between the response scores of the two groups, nor on the number of attempts, which, as could be expected, followed closely the results for the number of errors on tasks in the program.

Insert Table 2 about here

Field Dependence.

In the analyses of overall measures of time, error, the number of attempts and score field dependence appeared to be an influential factor. Field dependence interacted with the feedback treatment to affect the total first response times for tasks in both the first and second sections of the program (Tables 3 and 4). Thus field dependent subjects given Information feedback had generally shorter first response times than field dependent subjects given Knowledge of Results feedback. Similarly field dependent subjects given Information feedback had fewer first response errors and fewer overall errors than did their counterparts in the Knowledge of Results feedback treatment.

In general field independent subjects exhibited better performances than field dependent subjects however, trends indicated that both field dependent and field independent subjects performed better under differing feedback conditions.

Insert Tables 3 and 4 about here

The main effects for field dependence on response times ($F = 6.52$, $df = 2,17$, $p < .05$) indicated that field dependent subjects had longer response times than field independent subjects. Similarly the main effects for field dependence on first response error ($F = 7.51$, $df = 1,18$, $p < .05$) indicated that field dependent subjects made a higher number of errors than field independent subjects. Interaction effects for field dependence and the feedback treatment produced lower first response times ($F = 5,62$, $df = 1,17$, $p < .05$) and lower total response times for field dependent subjects under information feedback than under conditions of Knowledge of Results feedback. Further analyses revealed that the interaction of field dependence and the feedback treatment significantly reduced the response times for subjects on the more abstract tasks. ($F = 4.773$, $df = 1,21$, $p < .05$). Field dependent subjects under Information had reduced response times in comparison to field dependent subjects under conditions of Knowledge of Results feedback. Contrastingly field independent subjects performed better under conditions of Knowledge of Results feedback than under Information feedback. Under Information feedback these subjects had both higher response times and a higher number of errors.

Insert Figures 3 and 4 about here

Conceptual Tempo

In the analyses of the effects of conceptual tempo on the performance of subjects conceptual tempo appeared to have greater influence on performance on initial tasks, rather than on the program in general. The treatment interacted with conceptual tempo to effect the response time ($F = 5.724$, $df = 1,21$, $p < .05$) and the number of errors on the first abstract item in the program ($F = 4.232$, $df = 1,21$, $p < .05$), and conceptual tempo contributed significantly to the number of errors made by subjects on the first task of the program ($F = 7.702$, $df = 2,20$, $p < .05$). In the analyses of aggregated measures, using conceptual tempo groupings, a significant contribution was found for conceptual tempo on the total response time of subjects ($F = 4.534$, $df = 1$, $p < .05$).

Age and Sex

Main effects were found for age and sex on response times for some items in the program. Age and sex therefore appeared to have some effect on the performance of subjects, in terms of time, however the influence of these two variables appeared to be relatively minor.

DISCUSSION

It would appear that the influence of feedback and cognitive style may be determined by the type of task and form of presentation of the feedback. The interaction of field dependence with the feedback treatment on response times and first response times on the more abstract tasks in the second section of the program lend support to this proposal. In contrast to the first set of tasks, which were presented in the context of a tourist brochure, and in which the symbolism used in the visuals represented commonly known objects or concepts, the tasks in section two utilised abstract concepts and symbolism. Again where the feedback in the first set of tasks was presented entirely in verbal form, the feedback to tasks in the second set of tasks incorporated an initial visual presentation, followed by verbal information on subsequent incorrect attempts. The finding of interactions between field dependence and the feedback treatment on individual items in the second set of tasks, but not in the first set, further supports the idea that the interaction of cognitive style and feedback may be task and media related. The interaction of field dependence and the treatment on the two final figures in the second section of the program, is indicative that subjects use of feedback is task and media related.

The interaction of field dependence with the feedback treatment on the number of first response errors and the total number of errors may indicate that field dependent subjects might transfer information in the feedback message from one task to another. Within the limitations of this study it could not be determined if the information transferred was related to the explanation of the error or to the strategy for isolating relevent information. It is possible that the processing applied by the individual to initial responses influences subsequent errors. It appears, from the results of this study that field dependent subjects will make fewer first response errors, and fewer overall errors under conditions of information feedback than under conditions of Knowledge of Results feedback.

In discussing the effects of the interaction of field dependence and the feedback treatment on performance on the program, it should be noted

that, in contrast to field dependent subjects, field independent subjects showed longer first response times, longer overall response times and a higher number of errors under conditions of Information feedback than under conditions of Knowledge of Results feedback. Thus while the interaction of feedback and cognitive style suggested that the performance of field dependent learners under conditions of information feedback on visual problem-solving tasks was significantly improved over field Independent learners, the converse was true with the knowledge of results feedback.

The cognitive style measure of conceptual tempo appears to be more concerned with initial tasks rather than with the type of task. These indications follow the characteristics described by Kogan (1971). The interaction of conceptual tempo affected the number of errors on one item in the first set of tasks, and on the response time and number of errors on the first item in the second set of tasks. Although the finding of an interaction on the sixth item in the first set of tasks may appear to conflict with the idea of conceptual tempo being more influential in initial tasks, this result, in the context of the program offers support for the idea. The finding of a main effect for conceptual tempo on the initial task indicates that reflective subjects had a higher number of errors than impulsive subjects on this task. The requirements of the sixth problem in the program closely resembled the requirements of the first in terms of the type of transformation of information needed in order to solve the problem. Both tasks required subjects to associate symbolic codes with their referents in a legend and to search for missing information. Hence it would seem logical to suggest that reflective subjects, faced with a slightly modified version of the initial task, and in this instance, being familiar with the type of feedback incorporated in the program, made use of it in reducing the number of errors on this item. Similarly reflective subjects, again faced with an 'initial' task in the first item of the second set of tasks, and having no prior knowledge or experience of the type of feedback available in this set of tasks, made use of the feedback this time reducing response time as well as errors. While generalisations of the above results and discussion should be treated with some reservations, due to the small sample size, possible trends are indicated by the findings.

The results of the study indicate that the feedback treatment alone did not improve the performance of subjects in general. Subjects in the Information Feedback group had longer response times and a similar number of errors to their counterparts in the Knowledge of Results Feedback group. The lack of influence of the feedback treatment in improving subjects performance however may be due to the novelty of the tasks and the use of visual information (computer Graphics) rather than to the type of feedback treatment. The 'novel' tasks may have encouraged subjects to consider their answers more carefully than they would under different circumstances, before offering an initial response. It was observed that several of the subjects indicated particular interest in the presentation mechanism (computerised graphics) and it is possible that this interest influenced their responses and the consequent need for feedback. The combination of explanation and strategy for disembedding information tended to increase response time. This increase may have reduced the number of errors, however again it is possible that the repeated number of attempts reduced the influence of the feedback. Further research may treat the explanation in the feedback message and the strategy for isolating relevent information separately, and in conjunction with a variable number of attempts in order to determine the optimal combination

of information and the number of attempts for feedback messages.

Similar to the findings of Boysen and Thomas (1981) and Renzi (1974) the cognitive style measures did not predict overall performance under conditions of differing feedback. From the main effects for field dependence it would seem that field dependent subjects receiving information feedback may have longer response times, greater numbers of errors and a consequent higher number of attempts than field dependent subjects given Knowledge of Results. Correspondingly the main effect for conceptual tempo suggests that the number of errors and associated attempts taken by reflective subjects may not improve with information feedback. While the effects of the feedback treatment on its own and the use of the cognitive style measures as sole predictors or performance may be inadequate considerations in designing feedback to improve individual performance on CAL programs, consideration of the effects of the interaction of cognitive style and the feedback treatment gives indications of the way in which feedback may be designed to match cognitive style and consequently improve performance.

Relationship of the results to the major questions.

Three questions were posed at the commencement of this study:

1. Does feedback designed to incorporate an explanation of errors and strategies for disembedding information, assist students in improving their performance ?

The feedback in the information feedback did not assist subjects in improving their score, reducing the time taken, nor in reducing the number of errors made on visual problem solving tasks. In line with the findings described by Renzi (1974) and Boysen and Thomas (1981) very little variation in performance occurred between subjects in the knowledge of results treatment group and subjects in the information feedback treatment group. On the two items in which feedback was found to be an influential factor in the variance, no statistically significant differences were noted between the two groups. Similarly on the two items in which the feedback treatment influenced the number of errors made, the amount of variance was again not statistically significant. Thus, in answer to the above question, the feedback treatment did not assist learners in improving their performance.

2. Do subjects with different cognitive styles perform differently on tasks under conditions of differing feedback ?

The results of this study indicate that subjects with differing cognitive styles do perform differently under conditions of differing feedback. While the cognitive styles of the reflective and impulsive learner appeared to have little influence on the performance of these subjects the cognitive style of field dependence was found to be closely related to subjects performance in terms of time, error and the number of attempts on tasks. Perhaps because the field dependent dimension may be more closely related to the visual presentation of the tasks in this study than conceptual tempo, field dependent subjects in the Information feedback treatment group were found to have lower response times, lower error rates and to take fewer attempts than field dependent subjects in the Knowledge of Results Feedback Treatment group.

Field independent subjects were found to be negatively influenced by the presentation of information feedback. The results of the study show a trend towards the cognitive style of field dependence being more influential perhaps in first responses, than in subsequent attempts and the cognitive style of conceptual tempo appears to be more closely related to performance on initial tasks than to overall program performance. Further research may examine thes possibilities more closely.

3. Do selected measures of cognitive style interact with feedback designed to explain errors and provide strategies for disembedding information, to improve performance ?

In the light of the results of this study it would appear that selected measures of cognitive style do interact with the feedback designed to explain errors and provide strategies for disembedding information, to improve performance. The interactions of field dependence and the feedback treatment reduced the response time for field dependent subjects particularly in the second section of the program. Again the findings suggest that improved performance may be related to first responses which, in turn, may be effected by feedback in pre-ceeding tasks. Further , the interaction effects of field dependence and the feedback treatment on the number of errors made in the program suggests that the measures of cognitive style may interact with the feedback to improve performance. First response errors appeared to be more directly effected by the interaction. It might be implied from the findings of the study that the total number of errors made by subjects is likely to be related to the number of errors made on first responses.

The results of the study indicated that the interaction of feedback with cognitive style did not improve the performance of field independent subjects. Given information feedback field independent subjects took a longer time to respond than did field independent subjects given knowledge of results feedback. Further, field independent subjects in the information feedback treatment had longer response times than both field dependent and field independent subjects in the knowledge of results treatment group and longer response times than field dependent subjects in the information feedback group. Field independent subjects in the information feedback group had a greater number of errors than field dependents in both treatment groups. Feedback designed to explain errors and provide strategies for disembedding information may be more closely related to the response times of field independent subjects than to the number of errors made on tasks. The explanation of error and the provision of corrective strategies were not designed as separate treatment variables in this study. It might be suggested that future research examine the possible effects of interactions between feedback messages based on either an explanation of error or the provision of corrective strategies and the cognitive style of the learner in finding ways to maximise the performance of both the field dependent and field independent learner.

CONCLUSIONS.

This study used as its basis visual information, and the feedback combination was specifically constructed for problem-solving tasks. The flexible time response may not be common to all programs of this nature. Further, the number of repeated attempts available to subjects is not necessarily a component of programs in general. The widespread application of the results of this study should therefore be treated with

reservation. The following general guidelines for the design of feedback in courseware materials may be drawn from the study:

1. Field dependence does predict performance on problem-solving tasks involving the use of visual information. The more field dependent the subject the longer the first response time, the higher the number of first response errors and the higher the total number of errors made on tasks.

2. Conceptual tempo does not predict performance in terms of score, response time or error rate on problem-solving tasks involving the use of visual information.

3. The interaction of feedback (information feedback) and cognitive style improves the performance of learners with particular cognitive styles on problem-solving tasks involving the use of visual information. Both field dependent and reflective learners performed better when given feedback containing an explanation of errors and strategies for correcting errors, than when given only an indication that an error had been made.

4. The information in the feedback message is important in reducing the response time for field dependent learners. An explanation of errors and strategies for correcting them produced lower response times for field dependent learners than feedback giving only an indication that an error had been made.

5. To minimise errors for field dependent learners it is better to provide information feedback than knowledge of results. Feedback containing an explanation of errors and strategies for correction produced a lower rate of errors for field dependent learners than feedback providing only an indication of an error.

6. Reflective learners produced fewer errors when given feedback which contained an explanation of error and correction strategies than when given only indication of an error having been made.

7. Providing an explanation of error and strategies for correcting them does not improve performance of Field Independent learners. Field independent learners took less time and made fewer errors when given only an indication that an error had been made, than when given an explanation and a strategy for correcting the error.

The findings of the study discussed in this paper suggest a number of areas for future exploration: investigation of the impact of an explanation of error or the use of a corrective strategy independently of each other; the use of visual as opposed to verbal feedback in tasks using visual information; the relationship between cognitive style measures and the use of verbal or visual information in programs; the effect of visual encoding conventions on the performance of subject in programs using visual information and the requirements of feedback in the light of these conventions. Finally the impact of the cognitive style of learners apon the acquisition of information from visual materials, particularly those

employed in CAL courseware, and examination of means of maximizing the acquisition of information from these materials may benefit learners from further investigation.

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TABLE 1.

Means and Standard Deviations by Response Time

ITEM	INF (N=17)	KRF (N=13)	T(df)	p<
(Section 1)				
1	22.18 (12.97)	25.00 (19.40)	.48(28)	.64
2	61.35 (41.85)	98.77(118.07)	1.22(28)	.23
3	73.00 (69.78)	43.85 (12.36)	-1.48(28)	.15
4	169.94(127.61)	128.77 (63.36)	-1.06(28)	.30
5	75.76(132.61)	53.92 (64.57)	-0.54(28)	.59
6	77.53 (37.08)	59.85 (37.18)	-1.29(28)	.21
7	63.71 (47.07)	35.23 (19.55)	-2.04(28)	.05
8	64.76 (78.39)	143.69(290.47)	1.08(28)	.29
Total	608.24(266.63)	589.08(319.61	-0.19(28)	.85
(Section 2)				
9	233.65(206.09)	150.00(158.13)	-1.21(28)	.24
10	101.29 (1.21)	104.62 (10.45)	1.31(28)	.20
11	56.29(146.17)	44.54 (59.05)	-0.27(28)	.79
12	138.65(199.18)	64.69 (34.27)	-1.32(28)	.20
13	139.35 (86.43)	94.15 (62.04)	-.59(28)	.12
Total	665.06(444.22)	424.31(271.07)	-1.72(28)	.10
(Section 3)				
13	27.13 (15.67)	20.57 (19.17)	-0.86(21)	.40
14	33.50 (16.42)	31.00 (23.47)	-0.29(21)	.77
15	25.00 (14.30)	40.86 (74.93)	.84(21)	.75
Total	85.63 (26.19)	92.43 (76.03)	0.32(21)	.75
Total Program Response Time	1387.06(568.78)	1041.86(434.05)	1.43(21)	.17

Standard deviations are presented in parenthesis.

TABLE 2

Means and Standard Deviations by Response Error

ITEM	INF (N=17)	KRF (N=13)	T(df)	p<
(Section 1)				
1	.188 (.33)	.462 (.66)	1.87(28)	.07
2	.529(1.07)	.846 (.80)	0.89(28)	.38
3	.353(1.22)	.000 (.00)	-1.04(28)	.31
4	2.350(2.15)	1.080(1.40)	-1.84(28)	.08
5	.385(1.12)	1.180(1.63)	0.50(28)	.15
6	.824(1.70)	.231 (.60)	-1.19(28)	.24
7	.647(1.16)	.154 (.38)	-1.16(28)	.26
8	.353(0.61)	.769(1.24)	1.22(28)	.23
Total	3.350(6.78)	3.920(3.90)	-1.15(28)	.26
(Section 2)				
9	1.00 (1.28)	1.00 (.82)	.00(28)	1.00
10	.118(.49)	.231(.60)	.57(28)	.57
11	.118(.49)	.385(.87)	1.07(28)	.29
12	.706(1.05)	.796(.93)	.17(28)	.86
13	.471(.87)	.615(.77)	.47(28)	.64
Total	2.410(2.52)	3.00(2.97)	.59(28)	.56
(Section 3)				
4	0.000	0.000	0.00(21)	1.00
15	0.000	0.000	0.00(21)	1.00
16	.063(.25)	.143(.38)	2.29(21)	.55
Total	.063(.25)	.143(.38)	.61(21)	.55
Total Program Response Error	9.000(8.38)	6.430(6.97)	.71(21)	.49

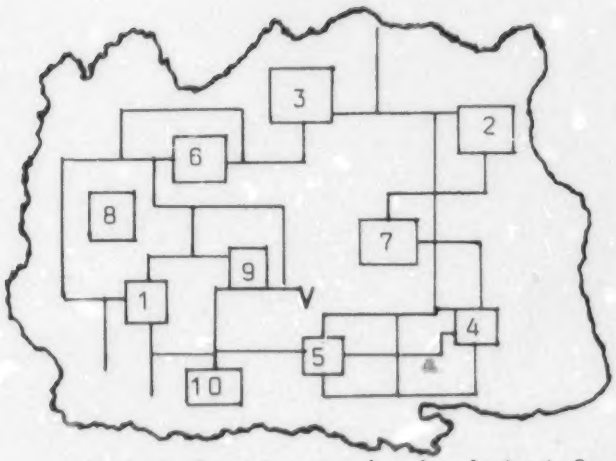
Standard Deviations are shown in Parentheses.

Table 3. Reduced regression models for the dependent variable response latency. Arranged by individual items and total responses.

ITEM	Variables	ΔR^2	B	F of equ(df)	p<	F of change	p<
1	Field Dependence	.14	-0.75	3.39 (1,21)	.08	3.39	.08
	Constant		37.29				
7	Treatment	.13	28.48	3.13 (1,21)	.09	3.13	.09
	Constant		6.76				
9	Conceptual Tempo x Treatment	.21	28.16	5.72 (1,21)	.03	5.72	.03
	Constant		202.02				
12	Field Dependence x Treatment	.75	3.87	62.30 (1,21)	.001	62.30	.001
	Constant		-27.16				
13	Field Dep x Treatment	.21	5.46	5.55 (1,21)	.03	5.55	.03
	Field Dependence	.14	-17.09	5.34 (2,20)	.01	4.26	.05
	Age	.20	-7.79	7.63 (3,19)	.002	8.32	.01
	Treatment	.12	-79.60	9.16 (4,18)	.001	6.78	.02
	Constant		614.42				
First Response Time -Section 2	Field Dep x Treatment	.32	17.79	10.05 (1,21)	.005	10.05	.005
	Field Dependence	.47	-60.82	38.41 (2,20)	.001	45.49	.001
	Age	.15	-17.80	110.33 (3,19)	.001	53.30	.001
	Constant		1500.37				
Response Time -Section 2	Field Dep x Treatment	.19	41.94	4.77 (1,21)	.04	4.77	.04
	Field Dependence	.31	-142.08	9.74 (2,20)	.001	12.16	.002
	Age	.08	-51.37	8.46 (3,19)	.001	3.48	.07
	Treatment	.09	-871.00	8.79 (4,18)	.001	4.77	.04
	Sex	.31	-588.58	126.97 (5,17)	.001	203.69	.001
	Constant		5564.49				
Overall First Response Time	Field Dep x Treatment	.24	24.39	5.64 (1,18)	.03	5.64	.03
	Field Dependence	.20	-80.04	6.53 (2,17)	.008	5.89	.03
	Age	.23	-33.99	10.58 (3,16)	.001	10.99	.004
	Sex	.12	-308.50	14.02 (4,15)	.001	8.83	.01
	Constant		3115.19				

Table 4 Reduced regression models for the dependent variable response error. Arranged by individual items and total responses.

ITEM	Variables	ΔR^2	B	F of equ(df)	p<	F of change	p<
1	Field Dependence	.35	-0.09	11.29 (1,21)	.003	11.29	.003
	Conceptual Tempo	.09	-0.12	7.70 (2,20)	.003	3.03	.097
	Treatment	.11	-0.73	7.58 (3,19)	.002	4.57	.05
	Field Dep x Treatment	.23	0.01	15.74 (4,18)	.001	18.87	.001
	Constant		37.29				
5	Field Dependence	.18	-0.08	4.75 (1,21)	.04	4.75	.04
	Constant		2.31				
6	Sex	.16	1.32	4.10 (1,21)	.06	4.10	.06
	Treatment	.11	0.94	3.83 (2,20)	.04	3.15	.09
	Constant		-2.85				
9	Conceptual Tempo x Treatment	.17	0.14	4.23 (1,21)	.05	4.23	.05
	Constant		1.02				
First Response Error -Section 2	Field Dependence	.16	-0.07	4.13 (1,21)	.055	4.13	.055
	Constant		2.95				
Number of Errors -Section 2	Field Dependence	.14	-0.12	3.42 (1,21)	.08	3.42	.08
	Constant		5.04				
Total First Response Errors	Field Dependence	.25	-0.27	5.62 (1,21)	.03	5.62	.03
	Field Dep x Treatment	.15	0.04	5.33 (2,20)	.02	4.03	.06
	Constant		7.12				
Total Response Errors	Field Dependence	.29	-0.94	7.51 (1,21)	.013	7.51	.013
	Field Dep x Treatment	.11	0.12	5.79 (2,20)	.012	3.16	.09
	Constant		21.55				



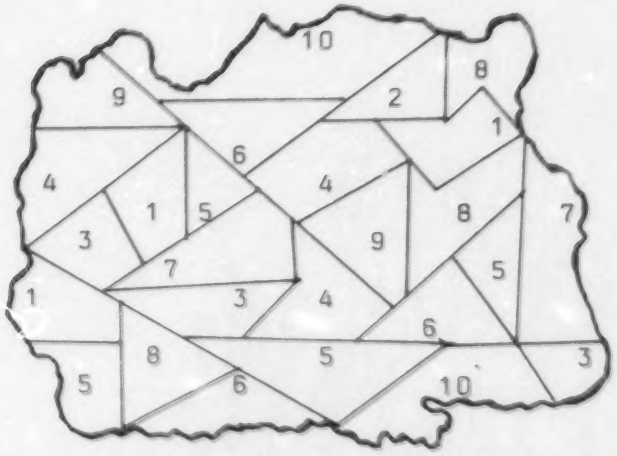
PORAH'S ROAD SYSTEM

V - village

—— roads

Each number represents a farmhouse

Which Farmhouse is isolated from the rest of the island ?



Land Allocation on Porah is very haphazard. Farmers have land in different parts of the island.

Which farmer has the smallest amount of land?

Figure 1. Sample tasks from the first section of the CAI program.

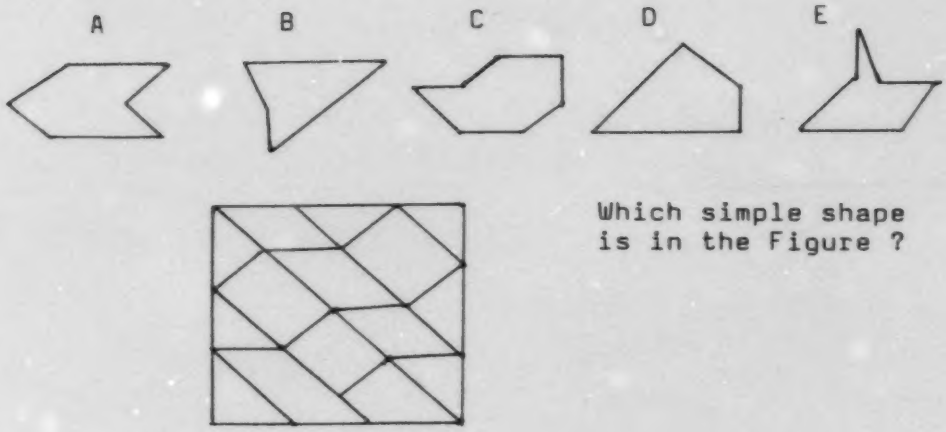
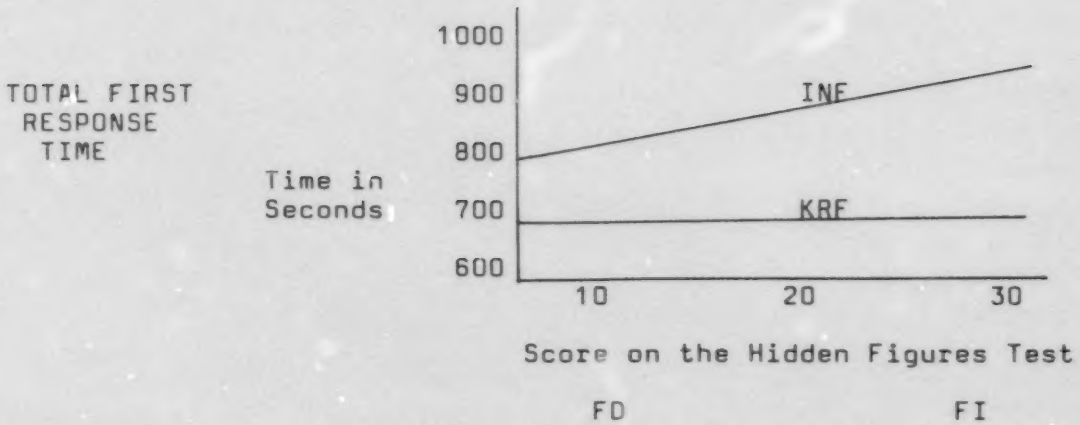
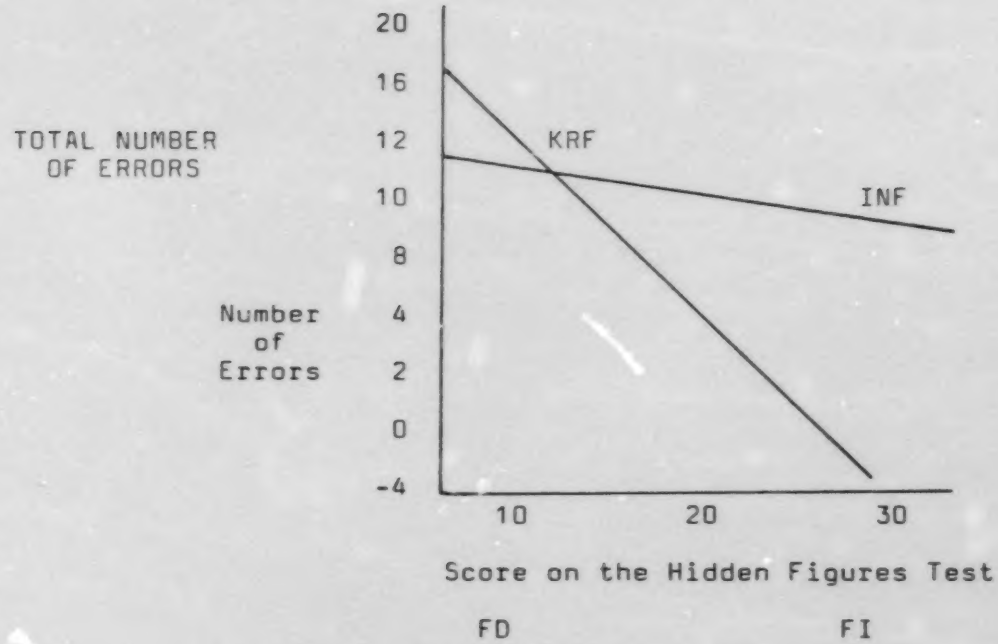


Figure 2. Sample task from the second section of the CAI program. Adapted from the hidden figures test (French, Ekstrom & Price, 1973).



KRF = Knowledge of Results Feedback Treatment
INF = Information Feedback Treatment
FD = Field Dependent
FI = Field Independent

Figure 3
Interaction of Field Dependence and Feedback Treatment
on overall first response time.



KRF = Knowledge of Results Feedback Treatment
INF = Information Feedback Treatment
FD = Field Dependent
FI = Field Independent

Figure 4
Interaction of Field Dependence and the feedback treatment on the total number of errors